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B.—LICHENS

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General.—Lichens are amongst the most attractive plants, yet they are usually regarded by the average botanist as merely typical examples of the phenomenon of symbiosis—though lichenologists are still debating as to the exact significance of the association of fungus and alga. This association, whatever it may be, and though it is likely that there is great variety in the relationship, enables these composite plants to play a peculiar part in the vegetation of the earth's surface.

That lichens have received a considerable amount of attention in the past is true, but nothing like what is their due considering their significance and importance. The number of students in the Empire is lamentably small, especially overseas. This paucity of workers doubtless is mainly due to the lack of convenient literature, but during the last few years the want has been met to a very great extent by the labours of Miss A. Lorrain Smith. It is to be hoped that the increasing interest apparent in the Home Country will soon spread to all parts of the Empire so that we shall obtain a reasonably comprehensive knowledge of its lichen flora. What results could be obtained from intensive studies overseas will be readily grasped from the fact that species new to science or new to the country are added annually to the British list.

Collection and Study.—Lichens are probably the easiest of all plants to collect. It is only necessary to allow them to dry with the customary precautions against moulds and insects, though it is advisable to flatten out by a weight the foliose and fruticose species while fresh, as they become fragile or friable when dry. In the case of saxicolous lichens, a portion of the stone on which they grow should be collected, and problems of transport will usually decide what amount is reasonable, though it should be remarked that the relation between different species occurring on a rock is often not easy to make out from small pieces. In order to be of value, however, specimens should show the fruiting stage, because, with rare exceptions, it is difficult to identify sterile lichens.

The ecological study of lichens presents many difficulties. The first is that of identification of specimens. This is not an easy matter, though not more difficult than with most other cryptogams. The fact that lichens are easily preserved, are perennial, and lose few of their characteristic features when dried, has obvious advantages. The collection and naming of lichens is an important activity, but in considering their ecology it is also extremely important to study their structure and biology. It is of interest to know that a certain species is restricted to a particular habitat, or that it is more catholic in its tastes, but the addition of information which helps us to grasp the factors upon which such distribution depends is, from the ecological point of view, all important.

Conditions of Life.—Owing to their peculiar constitution, lichens are able to withstand conditions of temperature which other plants ordinarily cannot survive. Certain fungi and bacteria are noteworthy for their powers of endurance, but, speaking generally, lichens may be said to be the most resistant of all plants. As a consequence they are to be found wherever there is vegetation, and act as " outposts " in deserts and the polar regions where no other forms of plant life are apparent.

Lichens are to be found even in the sunniest and most arid places in deserts, any paucity being in the lack of species able to adapt themselves to the conditions rather than in the number of individuals. Desert lichens are most frequently closely adnate and poorly lobed forms; these have a small evaporating surface and are also able to withstand being torn from their substrata by the driving sand of desert gales. Many species show a thickened cortex when growing in such situations: species of *Acarospora*, with strong protective cortex and compact structure, are characteristic. In polar regions lichens, principally crustaceous forms, spread extensively over rocks and stones which are not permanently covered with ice and snow. A snow covering usually has no unfavourable influence providing it disappears for a few weeks every summer, without leaving too much water, for, in too moist conditions, mosses and algæ gain the upper hand.[1]

Because of the need for photosynthesis light is necessary, though some few species, such as *Verrucaria muralis* and *Physcia obscura*, can grow immersed in the substratum or in almost total darkness. The colour of a species subjected to full sunlight is often darker than when growing in the shade. Moisture is necessary, as for all organisms, but the amount required by many species is exceedingly small.

Lichens are unable to endure smoke, a fact which accounts for their scarcity in and around towns. In London the only lichen to be seen is *Lecanora galactina*, subsp. *dissipata*, which occurs as black smudges on many Government buildings. The effect of atmospheric pollution on lichen vegetation is well brought out by Wheldon and Travis in their study in the manufacturing areas of South Lancashire (1915).

Dispersal of Lichens.—The methods of dispersal of different lichens also demand attention. In addition to the dissemination of the fungal spores and their chance encounter with the requisite alga, lichens may spread by the breaking off of small portions of the thallus, by means of the gemma-like soredia, and by isidia. In some lichens nodular excrescences become detached and blown about by the wind as in the " manna " lichen (*Lecanora esculenta*).

Nature of Substratum.—Lichens, like all other plants, are affected by the nature of the substratum on which they grow. The presence or absence of calcium carbonate has a marked effect on the lichen flora, there being calcicole and calcifuge as well as indifferent species. The effect of leaching is, moreover, as apparent with lichens as with flowering plants. As regards nutrition, lichens are largely independent of the substratum, and are to be found growing on all kinds of substances, iron, church windows, excreta, and so on, but owing to their frequency on the ground, on rocks, and on trees, they are generally grouped by lichenologists as terricolous, saxicolous and arboreal. It is only on rocks, however, that there are communities consisting solely of lichens.

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[1] Certain species are endemic either to the Arctic or to the Antarctic, but there is a high percentage of species common to both. Many of these, however, have world-wide distribution: *e.g.*, *Usnea melaxantha*, well known from Polar regions, has been recorded also from several parts of the Andes and from New Zealand. The Antarctic is more inhospitable to plant life than is the Arctic, as there is less accumulation of detritus.

Crustaceous saxicolous Lichens and Algæ.—The part crustaceous lichens play as pioneers of vegetation has been generally understood since the time of Linnæus, but the identity of the species concerned and the manner in which they act still offer considerable scope for research. In most accounts of succession from bare ground mention is made of crustose lichens as the pioneer vegetation. The alga is an essential part of the lichen-pioneer, and odd colonies of *Pleurococcus*, *Glœocapsa* or *Trentepohlia*, are sometimes apparent for a short time; on damp rocks, particularly when vertical, the last-named alga may form a pure community of a bright orange colour. Gelatinous blue-green algæ appear to be the first settlers on bare rocks in tropical regions, as, for example, in Krakatoa. The initial crustaceous lichens which inhabit bare rocks vary according to the nature of the substratum, the climatic conditions, the aspect, moisture relations, presence of nitrogenous matter, and so on; and the succession depends also on such environmental conditions. A totally different flora develops on calcareous and on siliceous rock (acid and basic), and rocks sloping at different angles show a change of species.

Though all lichens are to some extent nitrophilous, abundant nitrogenous material has its effect both on the initial plants and on the succession. This is seen on rocks frequented by birds. Lynge (1921) records that in Finmark the further north one goes the poorer are the conditions and the smaller the lichens and other plants. However, round the great fishery ports, where there is an abundance of offal and a great number of birds, nitrophilous and ornithophilous lichens develop luxuriantly and cover large areas: the fish flakes are yellow with *Xanthoria lychnea*, and on the shore this species, *Gyrophora arctica*, *Lecanora straminea*, *Xanthoria parietina*, and other nitrophilous lichens form conspicuous, luxuriant and extensive communities.

Succession on Rock Faces.—The initial crustaceous lichens, *Lecanora*, *Buellia*, *Placodium*, etc., which colonise bare rock, do not originally compete with one another to any extent, if at all.[1] In consequence of their excretion of carbonic and other acids the surface of the rock is gradually broken down at the place of contact. The manner in which the breaking down occurs has been studied during the last twenty years, by Bachmann in particular. In moist periods the secretions act beyond the margin of the thallus, and this enables the lichen to spread and also to start new colonies; eventually the whole of a favourable rock-face is completely covered. After a time the older thalli die at the centre and begin to break up, leaving an area of greater water-containing capacity. These areas are generally invaded by the larger foliose lichens such as *Parmelia, Physcia* and *Umbilicaria.* These, owing to their greater size and vigour, extend rapidly and gradually overgrow the crustaceous species, which die owing to loss of light and lack of water. Crustaceous lichens, taken as a whole, have very great difficulty in holding their own against other plants, being unable to resist even a slight covering. There is considerable competition for foothold between these species, dominance depending upon various factors. The size and structure of the foliose thallus enables it to retain moisture, and it is able to weather the surface of the rock to greater depths. The uneven surface of the thallus provides lodging places for the spores of mosses, which invade the rock when the foliose lichens, in their turn, break up at the centre. It is not always the moss which ousts the lichen. Cases are not infrequent where lichens destroy moss colonies, partly by parasitism but mainly by smothering.

Clements (1904), in his study of the weathering of granite and hard rocks in the Rocky Mountains, found that low mat-like herbs formed the fourth stage and caused the disappearance of the mosses by affecting the light and by root competition. Ostenfeld (1899) describes the lava streams of Iceland as being similarly colonised by crustaceous lichens, which are followed by a pure carpet of *Grimmia hypnoides;* Galløe (1920) confirms this and is inclined to believe that practically all the rock lichens found in Iceland can grow both on lava and on basalt. Comes (1881), on the other hand, investigating the lava blocks of Vesuvius, states that upon recent lava only faint traces of Protococcaceæ and diatoms can be found; lichens begin to appear after about seven years, the pioneer being the fruticose species *Stereocaulon vesuvium*, which is soon followed by other lichens and then by mosses. Such pioneer activity is unusual for *Stereocaulon*, which is usually quite late in its appearance, occurring, like *Cladonia* and other fruticose lichens, in somewhat damper situations, protected to some extent from wind, and on partially disintegrated rock, conditions which are met with in cracks and crevices of unweathered rock.

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[1] If rocks weather too rapidly, no lichens occur, as West (1912) found for the granite rocks of Shetland.

Frey (1922), in his study of the vegetation of the Grimsel region of the Swiss Alps, gives a full account of lichen succession. As a sample of such succession may be taken the development of a *Callunetum* in sub-alpine zones ; *Rhizocarpetum* → *Aspicilietum cinereæ* → *Gyrophoretum* → *Rhacomitrium-Cladonia* turf → *Callunetum.*

Many lichenologists have described the lichen communities to be found on different kinds of rocks. In studying succession it is necessary to take account of growth forms of lichens. For this purpose Frey subdivides the three main groups as follows : Crustose lichens he divides into three groups : (1) Thallus with a diffuse edge, *e.g.*, *Pertusaria ;* (2) thallus clearly effigurate, *e.g.*, *Biatorella testudinacea ;* and (3) thallus lobed, *e.g.*, *Placodium saxicola.* Foliose lichens fall into four groups : (1) edge with narrow lobes, thallus closely applied to substratum, *e.g.*, *Parmelia physodes ;* (2) edge mostly broadly lobed, thallus attached to substratum by rhizines, *e.g.*, *Parmelia saxatilis ;* (3) thallus with more or less prominent central holdfast, *e.g.*, *Umbilicaria ;* (4) thallus consisting of small lobes upright at the margins, *e.g.*, *Solorina.* Fruticose lichens are divisible into three groups : (1) thallus flat or grooved, strap-shaped, ascending, *e.g.*, *Cetraria ;* (2) thallus ascending with more or less twisted branches, *e.g.*, *Cladonia ;* (3) thallus branching, filamentous, pendulous or upright, attached at the base, *e.g.*, *Usnea.* Such a classification helps in generalising, but, as in all intensive work, the mode of growth of individual species must be studied to gain any real idea of the peculiar adaptations of their proper structure. The quadrat method is obviously the one which can best be applied to the study of succession.

Maritime Rocks.—That lichens inhabiting the rocks of the seashore occur in definite belts has been mentioned by many writers during the past century. In recent years these belts have been worked out in detail, particularly by Knowles (1913), for a portion of the Irish coast, and by Hayrén (1914) in his study of the seashore vegetation of West Sweden. At Howth five main belts can be distinguished on the siliceous rocks. These are, from below upwards: (1) Marine *Verrucaria* belt; (2) *Verrucaria maura* belt; (3) *Lichina* vegetation; (4) " Orange " belt; and (5) *Ramalina* belt. The marine *Verrucaria* belt includes those species which are submerged by the tide for a longer or a shorter period during the day, the dominant species being *Verrucaria microspora, V. striatula* and *V. mucosa.* The belt following this has *Verrucaria maura* as its dominant species, and normally occupies regions between high neap and high spring tides. The *Lichina* vegetation is somewhat intermingled with the preceding belt. The principal species are *Lichina pygmaea* which appears principally bordering the lower part of the belt, and *L. confinis* which occurs in the upper portion. The " orange " belt occupies stones and low shore rocks lying just above the ordinary high-tide level. In summer the vegetation shows as a brilliant orange, but in winter becomes greenish yellow. The principal species are *Xanthoria parietina* and a number of species of *Placodium.* The succeeding belt extends from just above high-water mark to the tops of the highest cliffs. This, the *Ramalina* belt, is dominated by *Ramalina siliquosa* and shows two zones: a lower one, always in reach of spray, in which the plants are fertile, and an upper one, consisting mainly of barren plants. In each belt there are other species, and the relative frequency of the constituents depends upon the varying factors. On the west coast of Ireland a " white " belt is found above the *Ramalina* belt, formed mainly of *Lecanora parella* and *L. atra.* The prevailing forms on calcareous maritime rocks are different, but no detailed study of these has been made. Where tufa forms the shore rock (as in parts of Iceland) it is, according to Galløe, quite devoid of lichens. In the Arctic the special coast lichens are a number of crustaceous species, such as *Lecanora straminea* and *Rinodina balearica.*

Sand Dunes.—The cryptogamic vegetation of sand dunes is quite as typical as the phanerogamic. The most characteristic members are lichens and bryophytes, which are sometimes the dominant plants of certain communities. Biologically they are important in humus formation, and so play a definite part in the sere. The lichens present are sun-lichens of a definite xerophytic type, whose thalli react to strong light by taking on a deep colour. They do not occur on the flat sands washed by the sea or on the mobile sand such as the small fore dunes and the seaward face of the larger dunes. On dunes with their surface slightly fixed by marram grass (*Ammophila*), however, Collemaceæ, such as *Leptogium scoticum*, *L. turgidum*, *Collema ceranoides* and *C. pulposum*, often occur as dark incrustations, being prominent in the cool, damp weather of autumn and winter. In addition to the mobility of the substratum, occasional flooding is also antagonistic to lichen development. The second line of dunes usually shows a fair abundance of lichens, though the number of species is restricted. Several rare species of *Lecidea* are to be found on the decaying vegetation, and with further accumulation of humus *Cladonia* spp. appear, together with several species of *Peltigera* and *Parmelia physodes*. As the dunes become fixed *Cladonia furcata* and other species become abundant, and it is the presence of this element that has gained for the fixed dune the name of "grey dune," in contradistinction to the "white dune." These are followed by fruticose lichens such as *Usnea*, *Ramalina* and *Evernia*. When there is an admixture of shingle saxicolous lichens make their appearance. The lichen vegetation of shingle depends upon whether the shingle is loose or bound, whether or not grasses are present, and whether the shingle is liable to frequent immersion. At Blakeney Point, in Norfolk (England), *Verrucaria maura* is confined to low shingle, which is covered by the tide several hours a day. *Placodium citrinum* does not occur where there is an absence of mud; *Lecanora badia* becomes conspicuously abundant as the sand increases. *Collema* spp. occur frequently on the mixture of mud and sand surrounding stones, whereas *Rhizocarpon confervoides* is ubiquitous.

Aquatic Lichens.—Lichens are rarely found completely submerged in water. The cosmopolitan *Dermatocarpon aquaticum* is the best-known species, though the classical example is the North American *Hydrothyria venosa*—closely allied to *Peltigera*—which occurs attached to rocks in the beds of streams, with its somewhat narrow fronds floating freely in the water. Along with the thick coriaceous *Dermatocarpon* a few species of *Verrucaria*, such as *V. œthiobola*, occur as a dark or greenish incrustation; also *Collema fluviatile* and species of *Polyblastia*.

Aquatic lichens may be grouped according to whether they are constantly submerged, frequently washed with splashes or spray, or only occasionally inundated: crustaceous species are the commonest type. This moisture relation results in zoning on lake sides.

Knowles has described such belts round mountain lakes in Waterford, where a belt of *Dermatocarpon miniatum* v. *complicatum*, six feet wide, occurred between the winter and summer level of the water, while below *D. aquaticum* formed another belt, mixed with several species of crustaceous lichens and the moss *Fontinalis*. On the flat shores of the Lake of the Woods, Macmillan (1894) records a *Dermatocarpon* belt followed by a *Biatora* belt and a *Cladina* belt; the width of the belts decreases with increasing steepness of slope, rounded rocky shores showing all the zones occurring within a couple of feet of the high-water mark.

Forests.—The lichen floras of forest and woodland have not been worked out to any extent on modern ecological lines, though long lists of species are given as terricolous on certain types of soil or as arboreal on the trunks of various trees. For over a century attention has been paid to the differences in the species on trees with smooth and those with rough bark. It is generally admitted that the chemical constitution of the bark has little or no effect but that physical characters are all-important.

Since lichens are usually sun-loving plants, they do not occur in woods where there is excessive shade. Thus beech woods, with close canopy and dense pine woods are comparatively free from lichen growth. Where light gains entrance, following either fire or fungal attack, lichens follow.

A distribution of lichens according to height on tree trunks can often be recognised. This seems to be more dependent on evaporation than on light, though both factors have their effect. *Usnea* and *Ramalina* occur where there is high evaporation and intense light, *e.g.*, on the crowns of the trees. It is a matter of observation in England that the sides of trees most exposed to rain and wind show the best development of lichens. Trees with smooth bark, such as hazel, beech, lime, and younger trees in general, bear only crustaceous species, many of them with very thin thalli, such as Graphidaceæ and Pyrenulaceæ, often half buried in the bark, and with *Trentepohlia* gonidia, though species of *Lecidea* and *Lecanora* also occur. As the bark becomes more rugged other types gain a foothold; thicker crustaceous species like *Pertusaria*, or larger and fruticose species. The rough surface retains moisture, and this is doubtless the important factor for the thick crustaceous forms, giving a secure foothold for the rhizines and holdfasts of the larger species.

Paulson (1919), in his account of Hertfordshire lichens, concluded that the presence or absence of lichens on trees is influenced to a considerable extent by the nature of the soil, though the connection was not discovered. Lichens, as a rule, do not long continue on a tree after it has fallen. This may be due to differences in light and moisture or even to chemical changes in the bark. Prostrate logs often have a characteristic lichen flora.

It is probable that as the lichen vegetation is more intensively studied it will be found to give aid in the sub-classification of woodlands. There are suggestions that the ground lichens and those of the trunks and crowns show considerable differences according to environmental conditions.

It is in tropical forests that lichens reach their greatest development. Several families and genera flourish best under tropical conditions, and many of our British species there reach a large size. The Hymenolichens—*Cora, Corella* and *Dictyonema*—occur on trees or on the ground all through the tropics. Another special group are the leaf lichens. These occur on coriaceous leaves and on fern fronds, disfiguring the leaves, though only *Strigula* is truly parasitic. The best-known family is Strigulaceæ, some of the species of which have a wide distribution in tropical and subtropical regions. A sterile species of *Strigula, S. Buxi*, has been recorded from Switzerland and from the Caucasus. The algal constituents of these lichens are *Phycopeltis* and *Mycoidea.* The alga apparently occurs alone on the leaf at first but afterwards is gradually invaded by the hyphæ of the fungus.

Heaths, etc.—The lichen vegetation of heath and moor is usually somewhat sparse because of the difficulty the plants have in obtaining sufficient light. In this country lichens usually occur on bare patches, no matter how these may have been formed. Differences in the species can usually be recognised according to the moisture-content of the soil. Where the soil is dry *Bæomyces roseus, B. rufus, Cladonia coccifera, C. macilenta, C. fimbriata*, and *Cetraria aculeata* occur, together with *Lecidea granulosa*, a species which is also sometimes met with on decaying tree trunks. *Peltigera spuria* occurs mainly where there have been fires. Where the soil is wet *Cladonia sylvestris* and *C. fimbriata* are the more usual species, being represented by special forms. Drifting soil and burrowing animals have a deleterious effect on lichen growth. However, on sand blasted areas on the East Anglian heaths *Cladonia* spp., *Cetraria islandica* and certain mosses are the chief agents in colonisation. In the same area, where smaller hummocks become undercut, the grass *Festuca ovina*, which originally occupied them, gradually dies and is replaced by various mosses, the summit eventually becoming clothed by the same lichen species. Wherever stones or rocks appear they are covered with lichens, the species depending mainly upon the nature of the substratum. According to Galløe, the commonest lichen of Danish heaths is *Cladonia rangiferina*, whereas in Iceland the commonest species are *Thamnolia vermicularis, Cetraria islandica* and *Lecanora tartarea.*

It should be noted that the thickness of a lichen covering may hinder the reproduction of higher plants, and in the Arctic circle may bring about a temporary transition stage of lichen-heath.

Tundra.—The lichens of the tundra have been frequently studied. In addition to extreme cold the tundra vegetation is subject to severe winds which drive away the snow and leave clear patches. The principal vegetation of the tundra consists of moss and lichen. The lichen tundra, or tundra heath, occupies the drier areas where the soil is shallow, and consequently is most frequent in hilly districts. Dry wind is the factor which determines the distribution of the lichens. Fruticose species, since they grow best where the air is still and moist, are rare in the extreme north, but occur in places where the snow lies for some time, *e.g.*, in depressions.

Cladina heaths—*C. rangiferina, C. alpestris* and *Stereocaulon coralloides*—are extremely widespread. *Cetraria* tundra has been described both from the Northern and Southern Hemispheres, as has also the more resistant *Alectoria* heath. These communities cover great areas, alternating with bare patches. Crustaceous lichens also occur, but these have not attracted much attention from travellers. *Lecanora tartarea* f. *frigida, L. epibryum*, and other species, however, occur in great quantity, covering the ground where it is kept free from snow by wind, or growing on mosses and spreading over stone and boulders. Kihlman (1890) describes how *Sphagnum* dies out and becomes covered with a crust of *Lecanora tartarea.* There is usually a gradual succession in which flowering plants, a series of mosses and then fruticose lichens—first *Cladonia* spp., then *Cetraria* spp., and *Platysma*, and finally *Alectoria*—become sickly and die in the order of their appearance. The whole hummock finally is covered with a lichen crust of *Lecanora*. According to Lynge, *Cladonia alpestris*, the reindeer moss of Norway, is the dominant lichen on poor, sandy soil in mountainous districts, where there are few or no reindeer, but if there are many reindeer these kick away the snow and eat the plants.[1] The constant repetition of this process alters the vegetation of large districts.

Arctic-Alpine Vegetation.—The effect of altitude is well seen in the distribution of lichens in mountainous districts.[2] It has been said generally that the higher one goes the less the percentage of foliaceous species. On high summits, where the snow covering lies for some time, the thalli are somewhat reduced, but where the period without snow is considerable the thalli are often very brightly coloured and of luxuriant growth.

Lichens and bryophytes contribute largely to alpine vegetation, and on mountain summits, exposed to extreme variation of temperature and humidity, are the main constituents of the community. Many of the lichens are strictly alpine, but a large number of lowland species are present in abundance. For instance, in Iceland, *Solorina crocea* and *Usnea melanoxantha* are the only species which, with certainty, can be regarded as exclusively mountain-height plants, the majority descending far into the lowlands. Lynge states that crustaceous lichens, which are alpine in Southern Norway, often descend to sea level in the north, *e.g.*, *Lecidea aglœa* and *Rhizocarpon alpicola :* here the most conspicuous of the truly alpine lichens are species of *Gyrophora*, *G. leiocarpa*, *G. fuliginosa*, etc., which extend to 2,000 metres and more, and are rarely found so low down as the upper tree limit. Frey, in his account of the vegetation of the Grimsel, describes how on the zenith flats, which are rough, partly through glacial action, three species of *Rhizocarpon*, *R. geographicum*, *R. alpicola* and *R. badioatra*, dominate in the pioneer community which, in the course of centuries, finally becomes a *Gyrophoretum*, with *Gyrophora cylindrica*, *G. reticulata*, *G. proboscidea*, etc., dominant, these compactly growing plants killing off the crustaceous species by forming a dense sward.

On the compact siliceous rock of the slopes in the alpine zone *Rhizocarpon* species are again the pioneers ; where there is full sunlight a *Biatorelletum cinereæ* is found, and this is followed in the subalpine zone by *Aspicilietum cinereæ ;* on northern exposures these are replaced by *Biatorelletum testudineæ* and *Pertusarietum corallinæ* respectively. On very moist rocks in sunlight *Ephebetum lanatæ* occurs, replaced in shade by the moss community of *Andræa petrophila.* These communities are altered by the dominance of nitrophilous species where the dung of marmots is abundant. The various communities can be matched by similar ones described from different localities. By such comparisons no doubt it will eventually be possible to relate the differences to various factors and indulge in generalisations.

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[1] Lichens have even served as food for man. Franklin, Richardson and Buck maintained life by eating " an old pair of leather trousers, a gun cover, a pair of old shoes with a little ' tripe de roche '."

[2] Lichens are recorded from Mount Everest up to 17,500 feet.

The work of Seifriz (1924) on the vegetation of Mount Gedeh in West Java shows that the altitudinal distribution of phanerogams is matched by that of lichens and mosses. From 4,600 feet to 5,500 feet, where the trees are chiefly *Liquidambar*, the lichen flora is very rich, the trunks of the trees being covered with crustaceous lichens, relatively few being found in the dark forest interior. Up to 7,000 feet *Podocarpus* is the dominant tree and, though moss-decked, shows very few lichens. From 7,000 to 8,000 feet the country is very open, and few mosses and lichens occur. Then in the foggy and wind-swept regions up to the lava flow of the old crater the small gnarled trees show few lichens in the lower portion, but are covered with foliose lichens in the upper. There is no lichen listed in the fifty species of the *Liquidambar* belt which occurs also in the twenty-one species of the fourth belt. On the lava floor of the old crater *Lecanora gelida* is very abundant.

Gibbs (1917) describes a remarkable community of *Cladonia* on the open summit of Koebré Mountain, 9,000 feet, in Dutch New Guinea. The summit forms a flat plateau with a hard surface of disintegrated quartz granite. The open character of the vegetation is apparently due to burning. Three species of *Cladonia, C. verticillata, C. didyma* and *C. coccifera,* spread over the whole area as a uniform grey carpet about 3 cm. high, displaced in certain parts by stretches of short *Pteridium* or *Gleichenia,* and in damper places by *Centrotopus.* There are indications that such an association occurs in other parts of New Guinea.

In the above sketch of lichen ecology the attempt has been made so to summarise a number of facts about lichen habitats that lines of investigation are suggested. It cannot be too strongly urged that it is by considering lichens—and fungi—in relation to other plants that their ecological importance will be seen. Some slight progress has been made in this direction, but there is practically an untouched field in the Empire.

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C.—SEAWEEDS

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General.—Our knowledge of marine vegetation is in most countries far behind that of the land flora. This condition is only to be expected since, in a large majority of cases, the algæ are not only less conspicuous but are of little economic importance. Exceptions to this rule occur in the Arctic and Antarctic, where the marine flora is more luxuriant than the terrestrial, and in certain other regions where algæ attract attention or are of some value, *e.g.*, the brown algæ of the Sargasso Sea, the Lithothamnia of coral reefs, the potash-yielding kelps of the Pacific, and the cultivated esculent species of Japan. From a scientific point of view an accurate knowledge of the marine flora and of the distribution of species is important and often of extreme interest, and such information as has been acquired has only whetted the enthusiasm of the algologist. The fact which stands out more clearly than any other, when geographical comparisons are attempted, is the need for accurate information. In the light of new knowledge the older records require confirmation ; indeed, wholesale revision of the published lists is sometimes necessary. In Europe, and even in Britain, precise and detailed knowledge has not yet been acquired, for in the recent intensive survey of Clare Island, off the West Irish coast, several of the most interesting species were found to be additions to the known flora of the region or to have been previously misdetermined (**2**).

Although the algologist, therefore, cannot claim that an algal survey of the British Empire is of such vital importance as a survey